Note: **Only these papers can be used; no other notes are allowed.**

Please answer each question concisely. Show your calculations.
You may (and in some cases, must) draw explanatory diagrams.
Label all axes and features on graphs and diagrams.

You may not use a calculator, computer, watch, smart device, or electronics of any sort. Irrelevant material will be ignored. Incorrect material will result in loss of points.

Table of constants and conversions

Speed of light: $c = 3 \times 10^{8}$ m/s
Electron charge magnitude: $e = 1.6 \times 10^{-19}$ C
Plank's constant: $\hbar = 1.1 \times 10^{-34}$ J-s
Gas constant: R = 0.08206 L-atm/mol-K = 8.314 J/mol-K = 1.987 cal/mol-K
Boltzmann constant: $k_B = 1.4 \times 10^{-23}$ J/K R/m
Electron rest mass: $m = 9.1 \times 10^{-31}$ kg
Proton rest mass: $M = 1.7 \times 10^{-27}$ kg
1 mole = 6.02×10^{23}

Energy Conversion Table

	eV	cm^{-1}	kcal/mol	kJ/mol	K	J	Hz
eV	1	8 065.73	23.060 9	96.486 9	11 604.9	$1.602\ 10 \times 10^{-19}$	$2.418\ 04 \times 10^{+14}$
cm^{-1}	$1.239\ 81 \times 10^{-4}$	1	0.002 859 11	0.011 962 7	1.428 79	$1.986\ 30 \times 10^{-23}$	$2.997\ 93 \times 10^{+10}$
kcal/mol	0.043 363 4	349.757	1	4.18400	503.228	6.95×10^{-21}	$1.048\ 54 \times 10^{+13}$
kJ/mol	0.010 364 10	83.593	0.239001	1	120.274	1.66×10^{-21}	$2.506\ 07 \times 10^{+12}$
K	0.000 086 170 5	0.695 028	0.001 987 17	0.008 314 35	1	$1.380\ 54 \times 10^{-23}$	$2.083\ 64 \times 10^{+10}$
J	$6.241\ 81 \times 10^{+18}$	$5.034\ 45 \times 10^{+22}$	$1.44 \times 10^{+20}$	$6.02 \times 10^{+20}$	$7.243\ 54 \times 10^{+22}$	1	$1.509\ 30 \times 10^{+33}$
Hz	$4.135\ 58 \times 10^{-15}$	$3.335\ 65 \times 10^{-11}$	$9.537\ 02 \times 10^{-14}$		$4.799\ 30 \times 10^{-11}$	$6.625\ 61 \times 10^{-34}$	1

You will find a periodic table for your reference on the next page.

Name Corinne Hickey Section # 361

Question 1 (10 points):
In Flint, Michigan, the water supply has become contaminated with lead.
If you were worried that other metals might be in the water, how would you determine which are present?
Describe how that information is obtained from your choice.

Can't use Ideal gas Law for liquids!!!

You can take the volume, pressure, and temperature of the water and use the ideal gas equation $PV=nRT$ and substitute $\frac{m}{M}$ for n. using the molar mass of lead, (207.2) you can calculate the total mass (in grams) of ~~lead that~~ is in the water. Subtracting the mass of the lead from the total mass you will get the mass of "water" left. To see if the remaining mass is pure water, you can again use $PV=\frac{m}{M}RT$ to calculate the molar mass of the substance. If the molar mass is not 18 (the molar mass of H_2O) then you will know that the substance is indeed contaminated. If the molar mass does equal 18, then the substance is pure water.

0

T = 273

Question 2 (15 points):

A 3-m long cylinder has three compartments with two separators and each compartment has a volume of 45 L. Initially, the separators are held in place and each compartment is open to the air, with the pressure in the room at 760 torr (1.0 atm), and the temperature at 0 °C. Assume that the air is an ideal gas.

a) How many moles of gas are in each compartment? (5 points)

$PV = nRT$

$\frac{1(45)}{R(273)} = n$

$R = .08206$

$\frac{45}{273(.08206)}$

$.08206 \times 273 = 22.40238$

$\boxed{\sim 2 \text{ mol}}$ +5

b) The connections from the compartments to the room are sealed off and:
the pressure in the right chamber is increased to 2.0 atm,
the pressure in the left chamber is increased to 3.0 atm, and
then the separators (pistons) are released and move without friction.

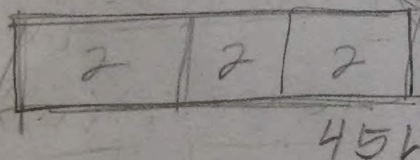
What is the pressure in each chamber? $\boxed{2 \text{ atm}}$

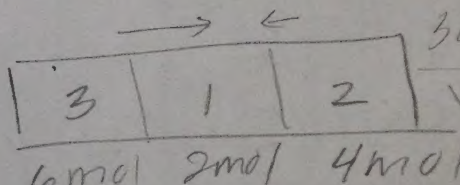
Where do the separators sit (draw a diagram) and why? (10 points)

$P = \frac{F}{A}$ ma

See back

n const





$V_{tot} = 45(3) = 135$

$V = \pi r^2 l$

$135 = \pi r^2 (3)$

$\pi r^2 = 45$

$A = 45$

$V = \frac{nRT}{P}$

$22.4(6)$

$\frac{PV}{RT} = n$

$\frac{13(45)}{22.4}$

$225 \overline{)135}$ 6

$22.4 \overline{)145}$

$22.4 \overline{)90}$ ~4

89.6

$V = 45(l)$

67.2

22.4

$P_{tot} = \Sigma P_{part}$

$3 + 2 + 1 = 6$

Question 3 (30 points):
Heat is added at a constant rate to water as the temperature is raised from -20 °C to 120 °C.
Draw the **time course** of the **temperature** and **density** (two different curves) and indicate the phase(s) at each temperature.
Label and concisely explain each stage of each curve and indicate where intermolecular bonds are made or broken.

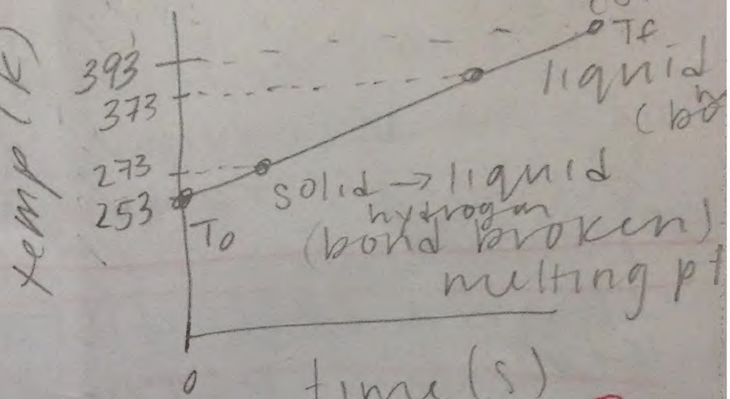
$\rho =$
straight b/c constant ra

@ 273 solid → liquid
@ 373 liquid → gas

$_0 = 253$ $\quad T_f = 393$
$M = 18$

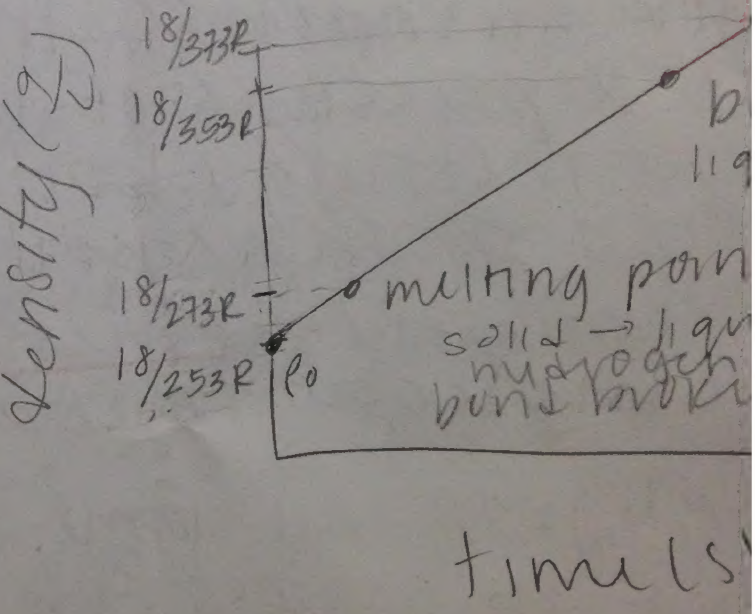
$\frac{g}{L}$

$\rho = \frac{m}{V}$ m constant
V increases
(assuming
not contained)



+10

so ρ decreases w/
temperature.
(inversely proportional)
constant rate so
slope of graph
is constant



$\Delta T = 140$ K

$\frac{m}{V} \to \frac{m}{140V}$

$V = \frac{nRT}{P}$

$\frac{m}{\ 0V} \to \frac{m}{120V}$

$\frac{nR(T+20)}{P} =$ melting

$\frac{nRT}{P} =$

$\frac{m}{\ }$

$\frac{nR(T+120)}{P} =$ boiling

$\frac{nR(T+}{P}$

ρ_0 $\quad$ 18 $\quad \rho_{boil}$

Question 4 (15 points):
How could you differentiate between ethylene (C_2H_4), nitrogen (N_2), and carbon monoxide (CO) using mass spectrometry?

aporization
onization (add electron
can move through
electric field)
incr. electroneg
ragmentation
lectric field/mols

You can use mass spectrometry on molecules to measure where ~~of light move through slits~~ and ~~measure each distance~~ using ~~differences between~~ them to ~~the molecules~~.

You can vaporize 1 mol of each at a pressure of 1 atm to fi[nd] true melting / boiling pts a[nd] match them w/ known valu[es]

You can use fragmentation to [break] the molecular bonds. Th[e]

$M(C_2H_4) = 28$
$M(N_2) = 28$
$M(CO) = 28$

All same M so can[not use] mass for 1 mol.

measure the mass of each (~~distance of light through slits~~) and to Molar mass (use

Question 5 (15 points):
Why are there warning signs indicating "ionizing radiation"?
Briefly explain in terms of energies and other related issues.
Give two examples of ionizing radiation.

NO

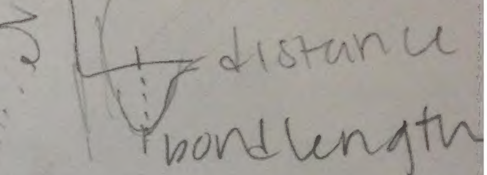
~~Ionizing radiation adds H^+ making molecules more electronigative allowing them to pass through el fields. Ionized molecules have str bonds with greater bond ener This could change the distance between molecules & disrupt nat molecules of organisms.~~

~~Radiation is used on cancer cells to disrupt molecular bonds, ultim killing the cells.~~

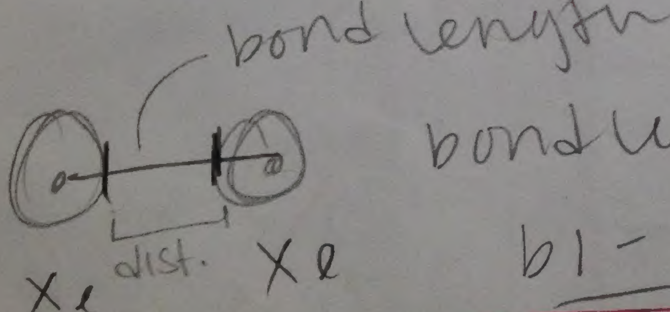
~~It can be used to identify mole elements by breaking the me into elements and findin molar masses and compari to the known values on th periodic table~~

Question 6 (15 points):
How would you experimentally determine the atomic radius of Xe?
Briefly explain your choice of technique in terms of length scales, energies, and related issues.

finding the bond length between two xenon atoms (Xe_2) by calculati the potential energy



you can measure how far apart the atoms are and as the bond length is measured from the center of th atoms, you can determine the len of 2 radii and divide that by 2.



bond length - distance =

$$\frac{bl - d}{2} = r$$

Extra credit #1 (2 points):
How are the gas constant, **R**, and the Boltzmann constant, k_B, conceptually related?

k_B (J/K)   R (J/mol K)   root mean speed

$k_B = R/mol$ $\sqrt{\frac{3RT}{M}} \Rightarrow \sqrt{3k_BT}$

kb is the amount of gas constant per mol. It can be substituted in equations

nRT → $PV = k_BT$ $\sqrt{\frac{3RT}{M}} \rightarrow \sqrt{3k_BT}$
ideal gas law   root mean speed

Extra credit #2 (2 points):
How are the energy units **Hz** and cm^{-1} conceptually related?

3.33565×10^{-11} Hz /cm

0